

and after the ingestion of rain with an overall ratio of water droplet flow to airflow, by weight, with a uniform distribution at the inlet plane, of at least four percent. Acceptable engine operation precludes flameout, run down, continued or non-recoverable surge or stall, or loss of acceleration and deceleration capability. It must also be shown after the ingestion that there is no unacceptable mechanical damage, unacceptable power loss, or other adverse engine anomalies. The rain ingestion must occur under the following static ground level conditions:

(1) A normal stabilization period at take-off power without rain ingestion, followed immediately by the suddenly commencing ingestion of rain for three minutes at takeoff power, then

(2) Continuation of the rain ingestion during subsequent rapid deceleration to minimum idle, then

(3) Continuation of the rain ingestion during three minutes at minimum idle power to be certified for flight operation, then

(4) Continuation of the rain ingestion during subsequent rapid acceleration to takeoff power.

(c) *Engines for supersonic airplanes.* In addition to complying with paragraphs (a)(1) and (a)(2) of this section, a separate test for supersonic airplane engines only, shall be conducted with three hailstones ingested at supersonic cruise velocity. These hailstones shall be aimed at the engine's critical face area, and their ingestion must not cause unacceptable mechanical damage or unacceptable power or thrust loss after the ingestion or require the engine to be shut down. The size of these hailstones shall be determined from the linear variation in diameter from 1-inch (25 millimeters) at 35,000 feet (10,500 meters) to ¼-inch (6 millimeters) at 60,000 feet (18,000 meters) using the diameter corresponding to the lowest expected supersonic cruise altitude. Alternatively, three larger hailstones may be ingested at subsonic velocities such that the kinetic energy of these larger hailstones is equivalent to the applicable supersonic ingestion conditions.

(d) For an engine that incorporates or requires the use of a protection device, demonstration of the rain and

hail ingestion capabilities of the engine, as required in paragraphs (a), (b), and (c) of this section, may be waived wholly or in part by the Administrator if the applicant shows that:

(1) The subject rain and hail constituents are of a size that will not pass through the protection device;

(2) The protection device will withstand the impact of the subject rain and hail constituents; and

(3) The subject of rain and hail constituents, stopped by the protection device, will not obstruct the flow of induction air into the engine, resulting in damage, power or thrust loss, or other adverse engine anomalies in excess of what would be accepted in paragraphs (a), (b), and (c) of this section.

[Doc. No. 28652, 63 FR 14799, Mar. 26, 1998]

#### § 33.79 Fuel burning thrust augmentor.

Each fuel burning thrust augmentor, including the nozzle, must—

(a) Provide cutoff of the fuel burning thrust augmentor;

(b) Permit on-off cycling;

(c) Be controllable within the intended range of operation;

(d) Upon a failure or malfunction of augmentor combustion, not cause the engine to lose thrust other than that provided by the augmentor; and

(e) Have controls that function compatibly with the other engine controls and automatically shut off augmentor fuel flow if the engine rotor speed drops below the minimum rotational speed at which the augmentor is intended to function.

[Amdt. 33-6, 39 FR 35468, Oct. 1, 1974]

### Subpart F—Block Tests; Turbine Aircraft Engines

#### § 33.81 Applicability.

This subpart prescribes the block tests and inspections for turbine engines.

[Doc. No. 3025, 29 FR 7453, June 10, 1964, as amended by Amdt. 33-6, 39 FR 35468, Oct. 1, 1974]

#### § 33.82 General.

Before each endurance test required by this subpart, the adjustment setting and functioning characteristic of each

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component having an adjustment setting and a functioning characteristic that can be established independent of installation on the engine must be established and recorded.

[Amdt. 36-6, 39 FR 35468, Oct. 1, 1974]

### § 33.83 Vibration test.

(a) Each engine must undergo vibration surveys to establish that the vibration characteristics of those components that may be subject to mechanically or aerodynamically induced vibratory excitations are acceptable throughout the declared flight envelope. The engine surveys shall be based upon an appropriate combination of experience, analysis, and component test and shall address, as a minimum, blades, vanes, rotor discs, spacers, and rotor shafts.

(b) The surveys shall cover the ranges of power or thrust, and both the physical and corrected rotational speeds for each rotor system, corresponding to operations throughout the range of ambient conditions in the declared flight envelope, from the minimum rotational speed up to 103 percent of the maximum physical and corrected rotational speed permitted for rating periods of two minutes or longer, and up to 100 percent of all other permitted physical and corrected rotational speeds, including those that are overspeeds. If there is any indication of a stress peak arising at the highest of those required physical or corrected rotational speeds, the surveys shall be extended sufficiently to reveal the maximum stress values present, except that the extension need not cover more than a further 2 percentage points increase beyond those speeds.

(c) Evaluations shall be made of the following:

(1) The effects on vibration characteristics of operating with scheduled changes (including tolerances) to variable vane angles, compressor bleeds, accessory loading, the most adverse inlet air flow distortion pattern declared by the manufacturer, and the most adverse conditions in the exhaust duct(s); and

(2) The aerodynamic and aeromechanical factors which might induce or influence flutter in those sys-

tems susceptible to that form of vibration.

(d) Except as provided by paragraph (e) of this section, the vibration stresses associated with the vibration characteristics determined under this section, when combined with the appropriate steady stresses, must be less than the endurance limits of the materials concerned, after making due allowances for operating conditions for the permitted variations in properties of the materials. The suitability of these stress margins must be justified for each part evaluated. If it is determined that certain operating conditions, or ranges, need to be limited, operating and installation limitations shall be established.

(e) The effects on vibration characteristics of excitation forces caused by fault conditions (such as, but not limited to, out-of balance, local blockage or enlargement of stator vane passages, fuel nozzle blockage, incorrectly schedule compressor variables, etc.) shall be evaluated by test or analysis, or by reference to previous experience and shall be shown not to create a hazardous condition.

(f) Compliance with this section shall be substantiated for each specific installation configuration that can affect the vibration characteristics of the engine. If these vibration effects cannot be fully investigated during engine certification, the methods by which they can be evaluated and methods by which compliance can be shown shall be substantiated and defined in the installation instructions required by § 33.5.

[Doc. No. 28107, 61 FR 28433, June 4, 1996, as amended by Amdt. 33-33, 77 FR 39624, July 5, 2012; 77 FR 58301, Sept. 20, 2012]

### § 33.84 Engine overtorque test.

(a) If approval of a maximum engine overtorque is sought for an engine incorporating a free power turbine, compliance with this section must be demonstrated by testing.

(1) The test may be run as part of the endurance test requirement of § 33.87. Alternatively, tests may be performed on a complete engine or equivalent testing on individual groups of components.

(2) Upon conclusion of tests conducted to show compliance with this